METHOD FOR SIMULATING A COMMUNICATION NETWORK THAT COSIDERS QUALITY OF SERVICE

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Field of the invention

The present invention refers to techniques for simulating communications networks such as, for example, radio-mobile cellular networks.

Simulation is an essential step in planning, designing, realising and managing such networks, above all in view of optimising network performances. In particular, simulation plays an important role both at check level for new planning network, and at update and optimisation level of performances of an already set-up network.

The invention has been devised paying particular care to the setting up of such simulation techniques as to produces parameters that can be used for evaluating the so-called Quality of Service (QoS) of the simulated network.

Description of the prior art

A communications network, such as a radio-mobile cellular network, offers quality of service when it is able to deal with the traffic produced by different applications in such to way as to satisfy their requests.

The quality of service is therefore an indicator of the network capability of offering a different management to different data flows. In general, the quality of service must be present along the whole data flow path (end-to-end).

It is known that there are cellular radio-mobile network system simulators characterised by an object architecture, such as disclosed, for example, in WO-A-

02/104055. According to the object approach, the elementary decomposition unit is not the operation (method), but the object, meant as model of a real entity (a real-world object).

It is known that in such simulators there are modules or devices adapted to simulate the behaviour of physical network devices. It is also known that a typical problem in developing system simulators, realised with such architecture, is linked to the need of managing the simultaneous simulation of calls realised by users that use services having different quality requirements.

It is also known that in such simulators it is possible to simulate different types of services, but these different services are completely defined previously inside the simulator and cannot be dynamically modified by a user. For example, in a simulator as disclosed in WO-A-02/104055 it is possible to simulate calls with GSM voice service and calls with GPRS data service. The user of such simulator can only set, at the simulation beginning, how many simulated users perform GSM voice calls and how many perform GPRS data calls.

In JP07283778A2 instead a system is disclosed for globally evaluating the arrangement or realisation of a cellular network, taking also into account costs and quality of supplied service. The case of having many QoS profiles is not dealt with.

Moreover, in US20030045298A1 a method is described for foreseeing the behaviour of an application using the results of a network simulation. It is provided to get the application responses when the speed and the simulated area position change. To do this, maps of QoS of the simulated area are used and, through the values of QoS being found in the maps, the behaviour of the

considered application is provided in the various positions inside the area. It is therefore only a different possible use of the simulation results that a traditional simulator is able to furnish with respect to a given application.

Purpose and synthesis of the present invention

In the known type of simulators, particularly for cellular networks, it is not possible for the user to dynamically describe the applications or the services to simulate (for instance: sounds, web browsing, streaming audio and/or video, e-mail,...). Besides it is not possible to associate to every simulated user a potentially different service from that of the other users. Particularly, it is not possible to dynamically define a QoS profile that contains the characteristics of a particular service; neither it is possible to define a QoS profile for every simulated user that is different from the profiles of the other users.

This means that the known solutions allow simulating a communications network through objects that model respective network devices, simulating through such objects the network services delivery according to respective quality profiles of service, that however are referred to a certain user typology; the various users, for instance "sound user", "data user", etc., are fixed, particularly as regards the service parameters (available band, transfer times, transfer speed,...).

In other words, in the solutions according to the known art, it is at most possible to only simulate a very narrow number of predefined "populations" of services or user typologies. The Applicant has observed that this corresponds to a representation that is a great deal far away from the current operating reality of a communications network, where a high number of

services corresponding to a wide range of possible delivery and use modes are mutually coexisting and interacting, particularly as regards the use of the network resources.

Object of the present invention is therefore overcoming the above-mentioned drawbacks, both the mode with which dynamically describing the different services inside the simulator, and the way of managing the possibility that every user can use a different service from those used by the other users, being able to be determine. Everything in a dynamic picture that corresponds in a more faithful and direct way to the operating reality of a communications network, in order to allow planning, designing, realising, managing and optimising the network in terms of QoS. This also as regards the possibility of defining new service profiles to simulate, in a flexible way and/or without having to proceed to the complete re-design of the correspondents simulation objects, also making the management of services at simulation level more slender.

According to the present invention, such object is reached due to a method having the characteristics recalled in specific way in the claims that follow. The invention also deals with the corresponding system (simulator), the simulation objects herein included, the network deriving from the application of the method according to the invention, as well as a corresponding information product loadable in the memory of at least one electronic computer and comprising portions of software code to perform the method according to the invention when the product is executed on a computer: in this context such term has to be deemed entirely equivalent to the mention of readable means from a computer comprising instructions to check a network of

computers in order to perform a method according to the invention. The reference to "at least one electronic computer" is obviously aimed to show the possibility to perform the solution according to the invention in a de-centralized context.

Substantially, the currently-preferred embodiment of the invention provides for the selective identification of at least one quality of service profile. The simulation objects are then dynamically configured then for simulating the service delivery corresponding to the quality of service profile that has been selectively identified.

In the currently-preferred embodiment, the solution herein described solves the above-mentioned technical problem through one or more of the following innovative elements:

- introduction of such a typology of "quality of service profile" that every profile describes the quality requirements of a single service; by setting different requirements, the profile defines a different service;

- identification of parameters that define every service: the service quality requirements can be expressed through different parameters (service class, transfer delay, maximum bit rate respectively for uplink section and for downlink section, guaranteed bit rate respectively for uplink section and for downlink section); every value given to service quality parameters univocally defines a type of service. Such parameters are grouped together and constitute the attributes of the single "quality of service profile": the simulator user can set as input the values of different parameters of every profile of quality, dynamically varying the simulated services;

- possibility to define different service quality profiles for every simulated user: every simulated user has at least his own "quality of service profile" that can be set by the user; in this way it is possible to perform simulations in which every user can use a different service from those used by the other users.

It is thereby possible to determine both the mode with which the different services inside the simulator can be determined, and the way of managing the possibility that every user can use a different service from those used by the other users.

The simulation thereby corresponds in a more faithful and direct way to the operating reality of a communications network, and allows planning, designing, realising, managing and optimising the network in terms of QoS.

It is then allowed to define new service profiles to simulate in a flexible way and/or without having to proceed with the complete re-design of the corresponding simulation objects, also making the service management at simulation level more slender.

Brief description of the attached drawings

The invention will be described, merely as a non-limiting example, with reference to the attached drawings, in which:

- figure 1 is a functional approximate diagram of the simulator of the herein-described type,

- figures 2 and 3 show possible configurations of the aforesaid simulator,

- figure 4 shows a possible definition of quality of service profile within a simulator of the herein-described type, and

- figures 5 to 8 are exemplifying diagrams of the operating modes of the herein-described simulator.

Detailed description of an embodiment of the invention

Figure 1 shows the architecture of a simulator 10 comprising an engine 11 in which all typical functionalities for managing the simulation of a telecommunications network, such as a radio-mobile network, are present, namely:

- Parameter Manager 11a,
- Event Scheduler 11b,
- Factory Manager 11c, and
- Statistic Manager 11d.

There is also a device package 12 in which the different devices 13 are contained, representative of the physical network devices and the objects related to the scenario to simulate.

Every devices contains different modules related to the different functionalities managed by the device itself.

Such a simulator, working in general among a set of input signals I and a set of output signals, can be implemented, for instance, on a computer with Intel Pentium III processor and Microsoft Windows operating system, using Microsoft Visual I Studio 6.0 development environment and ANSI C++ programming language.

Always as an example, some possible devices 13 present in the package 12 are:

- radio-mobile terminal or MS/UE (Mobile Station/User Equipment),
- node MSC (Mobile Switching Center),
- node SGSN (Serving GPRS Support Node), and
- node GGSN (Gateway GPRS Support Node).

Every device 13 present in the package 12 contains in turn the modules related to the different functionalities and to the different protocols that it implements.

The modules contained inside devices 13 are separated in Control Plane CP and User Plane UP modules. The Control Plane CP modules are related to the functionalities of installation, management and release of the connection; the User Plane UP modules are related to the communication functionalities when the connection is active.

The solution herein described focuses, in particular, on the Control Plane CP characteristics as regards QoS functionalities for 2G (second Generation), 2.5 G and 3 G (for example GSM, GPRS and UMTS) radio-mobile systems.

The Control Plane modules belong to two families, according to the type of connection: Circuit Switched (CS) (namely as circuit switching) or Packet Switched (PS) (namely as packet switching).

In the CS connection case (see figure 2), attention is focused on modules MT_CC (Mobile Terminal Call Control) 21a and MSC_CC (Mobile Switching Center Call Control) 22b that can respectively be found in two devices MS/UE 21 and MSC 22.

Modules MT_CC 21a and MSC_CC 22b manage the start and release of a call in case of CS (Circuit Switched) circuit services; during the start of a call, said modules communicate the type of service they need, pointing out its related parameters, to respective modules I1 and I2 of radio interface GSM or UMTS.

In device MSC 22 a module MSC_CC 22b is present for every active radio-mobile terminal; the allocation of different modules MSC_CC 22b is the responsibility of a module MSC_CC_Manager 22a.

The module MSC_CC_Manager 22a manages different typologies of modules MSC_CC 22b.

Every module typology corresponds to a different QoS profile. Particularly, module MSC_CC_Manager 22a

obtains the typology to be use for allocation directly from radio-mobile terminal MS/UE 21, where the type of module MSC_CC is stored in an attribute called "MSC_CC_CLASS_TYPE."

In case of PS connection (see figure 3), the attention is focused on modules MT_SM 31a (Mobile Terminal Session Management) and SGSN_SM 32b (Serving GPRS Support Node Session Management) present in respective devices MS/UE 31 and SGSN 32.

Modules MT_SM 31a and SGSN_SM 32b manage the start and release of the call in case of PS (Packet Switched) packet services; during the start of the call said modules communicate the type of service they need, pointing out its related parameters, to modules I1 and I2 of related radio interface GPRS or UMTS.

In the device SGSN 32 there is a module SGSN_SM 32b for every active radio-mobile terminal; the allocation of different modules SGSN_SM 32b is the responsibility of module SGSN_SM_Manager 32a. Module SGSN_SM_Manager 32a manages different typologies of modules SGSN_SM 32b.

Every module typology corresponds to a different QoS profile. Particularly, module SGSM_SM_Manager 32a obtains the typology to be used for allocation directly from radio-mobile terminal MS/UE 31, where the type of module SGSN_SM is stored in an attribute called "SGSN_SM_CLASS_TYPE."

In every radio-mobile terminal MS/UE, module MT_CC 21a is present if radio-mobile terminal 21 manages CS (Circuit Switched) connections; instead, module MT_SM 31a is present if radio-mobile terminal 31 manages PS (Packet Switched) connections.

The above-stated concepts are however well known to the skilled experts in the art: the previously-provided synthesis is primarily aimed therefore to

facilitate the correct understanding of the herein described arrangement in one of its typical use context.

The herein described arrangement provides for the introduction of a "Quality of Service or QoS profile" of the type shown in figure 4, aimed to describe the parameters related to a type of simulated service.

With reference to a typical context of radio-mobile network, the considered parameters, defined in the standard (in a way that is largely independent from the technology: GSM, GPRS, UMTS, etc.) are as follows:

- Traffic class 41: one among four possible values CONVERSATIONAL, STREAMING, INTERACTIVE, BACKGROUND;
- Transfer delay 42: maximum transfer time of a data unity by transmitter to receiver;
- Guaranteed bit-rate UL 43: guaranteed transfer speed for data that are transmitted by the radio-mobile terminal toward the network;
- Maximum bit-rate UL 44: maximum transfer speed for data that are transmitted by the radio-mobile terminal toward the network;
- Guaranteed bit-rate DL 45: guaranteed transfer speed for data that are transmitted by the network toward the radio-mobile terminal; and
- Maximum bit-rate DL 46: maximum transfer speed for data that are transmitted by the network toward the radio-mobile terminal.

A particular QoS profile identifies a type of service inside the simulator.

The simulator user can specify in input data the values of parameters of every simulated QoS profile.

The herein described solution provides particularly for the introduction, for every simulated user, of a parameter "QoSparams" relative to a particular QoS profile.

In the herein-shown embodiment (that must be remembered as such) in modules MT_CC 21a, MT_SM 31a, MSC_CC 22b and SGSN_SM 32b a parameter "QoSparams" is therefore present that corresponds to a QoS profile related to the single radio-mobile terminal: then, different radio-mobile terminals MS/UE can have modules MT_CC/MSC_CC or MT_SM/SGSN_SM with different parameters "QoSparams", and therefore they can simulate different services. It is thereby possible to define for every user his customised QoS profile.

The implementation of parameter "QoSparams" is performed in the ANSI C++ programming language by means of a class "QoSparams" included as follows:

```
class QoSparams
{
public:
  / / COSTRUCT-DESTRUCT
  QoSparams ();
  virtual ~QoSparams ();
  virtual void empty ();

  virtual string toString () const;

  / / OPERATORS
  virtual void operator = (QoSparams & b);
  virtual void operator = (QoSparams * b);
  virtual void Dump(void);

  / / METHODS GET
  inline TRAFFIC getTraffic(void)const {return
trafficClass;}
  inline Time gettransferDelay(void)const {return
transferDelay;}
```

```
        inline double getUL_guaranteedBitRate(void)const
    {return UL_guaranteedBitRate;}
        inline double getDL_guaranteedBitRate(void)const
    {return DL_guaranteedBitRate;}
        inline double getUL_maximumBitRate(void)const
    {return UL_maximumBitRate;}
        inline double getDL_maximumBitRate(void)const
    {return DL_maximumBitRate;}
        inline int getTHP(void)const {return THP;}
        / / METHODS SET
        inline void setTraffic(TRAFFIC newTraffic)
    {trafficClass = newTraffic;}
        inline void settransferDelay(Time newTime)
    {transferDelay = newTime;}
        inline void setUL_guaranteedBitRate(double
    newBitRate) {UL_guaranteedBitRate=newBitRate;}
        inline void setDL_guaranteedBitRate(double
    newBitRate) {DL_guaranteedBitRate=newBitRate;}
        inline void setUL_maximumBitRate(double
    newBitRate) {UL_maximumBitRate=newBitRate;}
        inline void setDL_maximumBitRate(double
    newBitRate) {DL_maximumBitRate=newBitRate;}
        inline void setTHP(int _THP) {THP=_THP;}
        / / SERIALIZE
        virtual void serialize(PersistenceManager & p);
      protected:
        / / MEMBERS
        TRAFFIC          trafficClass;
        Time             transferDelay;
        double           UL_guaranteedBitRate;
        double           DL_guaranteedBitRate;
        double           UL_maximumBitRate;
        double           DL_maximumBitRate;
        int              THP;
```

```
private:
  //
  DECLARE_FACTORY(QoSparams);
  //

};
```

The herein described solution provides for an operation able to respect the QoS profile both for calls "originated" from radio-mobile terminals MS/UE and for calls originated from the network (called "terminated").

In case of an "originated" call of the CS (Circuit Switched) type from radio-mobile terminal MS/UE, the module MT_CC 21a directly sends its own parameter "QoSparams" to the module MSC_CC 22b, that communicates it to the modules related to radio interface GSM or UMTS that establish the connection according to the type of service pointed out in "QoSparams."

Figure 5 refers to the case of an "originated"call of the CS (Circuit Switched) type described as follows. The call originates in general from a given terminal (for instance a i-th terminal TMi or a j-th terminal TMj).

In step 1, the request for starting the connection is sent by the radio-mobile terminal toward the network, particularly to device MSC; in the starting request, module MT_CC 21a in calling terminal inserts parameter "QoSparams" with value equal to its own parameter "QoSparams."

In step 2, the device MSC receives the starting request and proceeds, through module MSC_CC_Manager, to the allocation of module MSC_CC related to radio-mobile terminal MS/UE. Depending on parameter "QoSparams" received by the device MSC in the starting request,

module MSC_CC_Manager 22a determines the type of module MSC_CC to be allocated and allocates it for radio-mobile terminal MS/UE.

In step 3, the method of starting the call towards terminal TMi or TMj proceeds by using the correct QoS profile.

In case of an "originated" call of the PS (Packet Switched) type from radio-mobile terminal MS/UE, the operation is analogous to that related to the originated call CS: module MT_SGSN 31a directly sends its own parameter "QoSparams" to module SGSN_SM 32b, that communicates it to modules related to the radio interface GPRS or UMTS that establish the connection according to the type of service pointed out in "QoSparams."

Figure 6 shows the case of an "originated" call of the PS (Packet Switched) type described as follows. Also in this case reference is made to a call originated from i-th terminal TMi (or from j-th terminal TMj).

In step 1, the starting request of the connection is sent by the radio-mobile terminal towards the network, particularly to device SGSN; in the starting request, module MT_SM 31a in terminal TMi inserts the parameter "QoSparams" with a value equal to its own parameter "QoSparams."

In step 2, the device SGSN receives the starting request and proceeds, through module SGSN_SM_Manager 32a, to the allocation of module SGSN_SM related to radio-mobile terminal MS/UE. Depending on parameter "QoSparams" received by device SGSN in the starting request, module SGSN_SM_Manager determines the type of module to be allocated SGSN_SM and allocates it for radio-mobile terminal MS/UE.

In step 3, the method of starting the call from terminal Tmi or TMj proceeds using the correct QoS profile.

In case of "terminated" call the indication of start of the connection is not sent by radio-mobile terminal MS/UE, but originates from simulated network devices. The starting request for a connection arrives therefore to modules in devices MSC 22 or SGSN 32 without any indication of what QoS profile to use.

The mechanism shown here as an example allows obtaining the QoS profile related to the radio-mobile terminal MS/UE to which the call is destined. As previously described, modules MSC_CC_Manager 22a and SGSN_SM_Manager 32a are respectively able to allocate different types of modules, respectively MSC_CC 22b and SGSN_SM 32b, directly obtaining it from radio-mobile terminal relative MS/UE (respectively attributes "MSC_CC_CLASS_TYPE" and "SGSN_SM_CLASS_TYPE").

Every type of modules MSC_CC or SGSN_SM is related therefore to a specific QoS profile (for instance SGSN_SM_QoS_A is related to module SGSN_SM with QoS profile type A, MSC_CC_QoS_C is related to module MSC_CC with QoS profile type C,...).

Figure 7 shows the case of an "terminated" call of the CS (Circuit Switched) type, described as follows.

In step 1, the starting request of the connection reaches device MSC from the network, with the indication of its related radio-mobile terminal MS/UE.

The device MSC sends the request to module MSC_CC_Manager for allocating module MSC_CC related to radio-mobile terminal MS/UE. In step 2, module MSC_CC_Manager obtains from radio-mobile terminal MS/UE which type of module MSC_CC and allocates it.

In step 3, the method of call start proceeds using the correct QoS profile.

Figure 8 finally shows the case of an "terminated" call of the PS (Packet Switched) type, described as follows.

In step 1, the starting request of the connection reaches device SGSN from the network, with the indication of its related radio-mobile terminal MS/UE.

The device SGSN sends the request to module SGSN_SM_Manager for allocating module SGSN_SM related to radio-mobile terminal MS/UE. In step 2, module SGSN_SM_Manager obtains from radio-mobile terminal MS/UE which type of module SGSN_SM and allocates it.

Finally, in step 3, the method of call start proceeds using the correct QoS profile.

The herein described solution brings about some essential advantages.

Firstly, it is possible to define the parameters that describe every service from the point of view of quality requirements, using in the simulations a quality of service profile for every service that is desired to simulate.

It is then possible to define different QoS profiles for every simulated user and, accordingly, every simulated user can potentially use a different service from those used by the other users. The user, by filling-in his input data I, can then define the different services setting the parameters values of the QoS profile of every service to simulate.

Moreover, the operation for managing the QoS profiles provides both cases in which simulated calls are originated from mobile and terminated to mobile.

In case of simulation of originated calls, parameter "QoSparams" is specified by simulated terminal to blocks responsible for starting the connection during the connection starting procedure.

In case of simulation of finished calls, parameter "QoSparams" is adequately taken by the simulated terminal from the blocks responsible for starting the connection.

The implementation of the described simulator can be realized with any type of computer, like Intel, SUN, Apple,... and with any operating system (Windows, Linux, Unix, MAC OS...). The use of the ANSI C++ programming language is only a possible choice since the implementation can also be performed in other programming languages, like Java, Delphi, Visual Basic,...

The choice of ANSI C++ language appears to be currently preferential in view of the good programming flexibility offered by said programming language and of the high level of obtainable performances in the finished program in terms of execution speed.

In the description the term simulated service means everything that deals with the transport step of user data, without needing to consider other service steps (set-up, re-configuration, service termination, etc.) that can anyway have an impact on the quality perceived by users.

This "approximation" - that must not be read in a limiting sense for the invention - is suggested by different reasons.

Firstly, it is usually scarcely practical to simulate multiple services in all their steps since there are various factors (service architecture, protocols involved in the various steps, apparatuses involved etc.) particular for the various services that can change from implementation to implementation of the same service.

It is usually then scarcely meaningful to perform simulations on the particular implementations of the

various services since anyway, for reasons of modelling, scarcely results would be obtained.

Nevertheless, the invention can also be used by taking into account, on the basis of present description, the service steps, as for example set-up, re-configuration, service termination, etc. or part of them, in cases in which it is useful to consider the above steps for evaluating QoS.

The invention can be used in cellular networks simulators that simulate other systems besides the mentioned GSM, GPRS and UMTS. The invention can be used in telecommunications networks simulators of the fixed or mixed fixed/mobile types, for instance networks for which the management of the quality of service is provided as described in the present invention.

The skilled technicians in the field will immediately appreciate the fact that the invention does not necessarily deals only with the simulation of cellular radio-mobile networks: the invention can in fact be also used in other types of simulators, where there is an architecture similar to modules and devices complying with real physical equipment and where it is necessary to communicate, among the various modules/devices, the parameters related to simulated functionalities.

It is therefore evident that, having stated the principle of the invention, the realisation parts and the embodiments can be widely changed with respect to what is described and shown, without anyway departing from the scope of the present invention, as defined by the attached claims. This is valid particularly, but not exclusively, as regards the possible extension of the herein described solution to simulators in which every simulated user is associated with many quality of service profiles referred to services or classes of

different services aimed to mutually interact (for instance audio/video streams aimed to be simultaneously exploited).